

**EXHIBIT A**  
**THE DIFFERENCES BETWEEN THERMOPLASTIC AND THERMOSET POLYMERS**

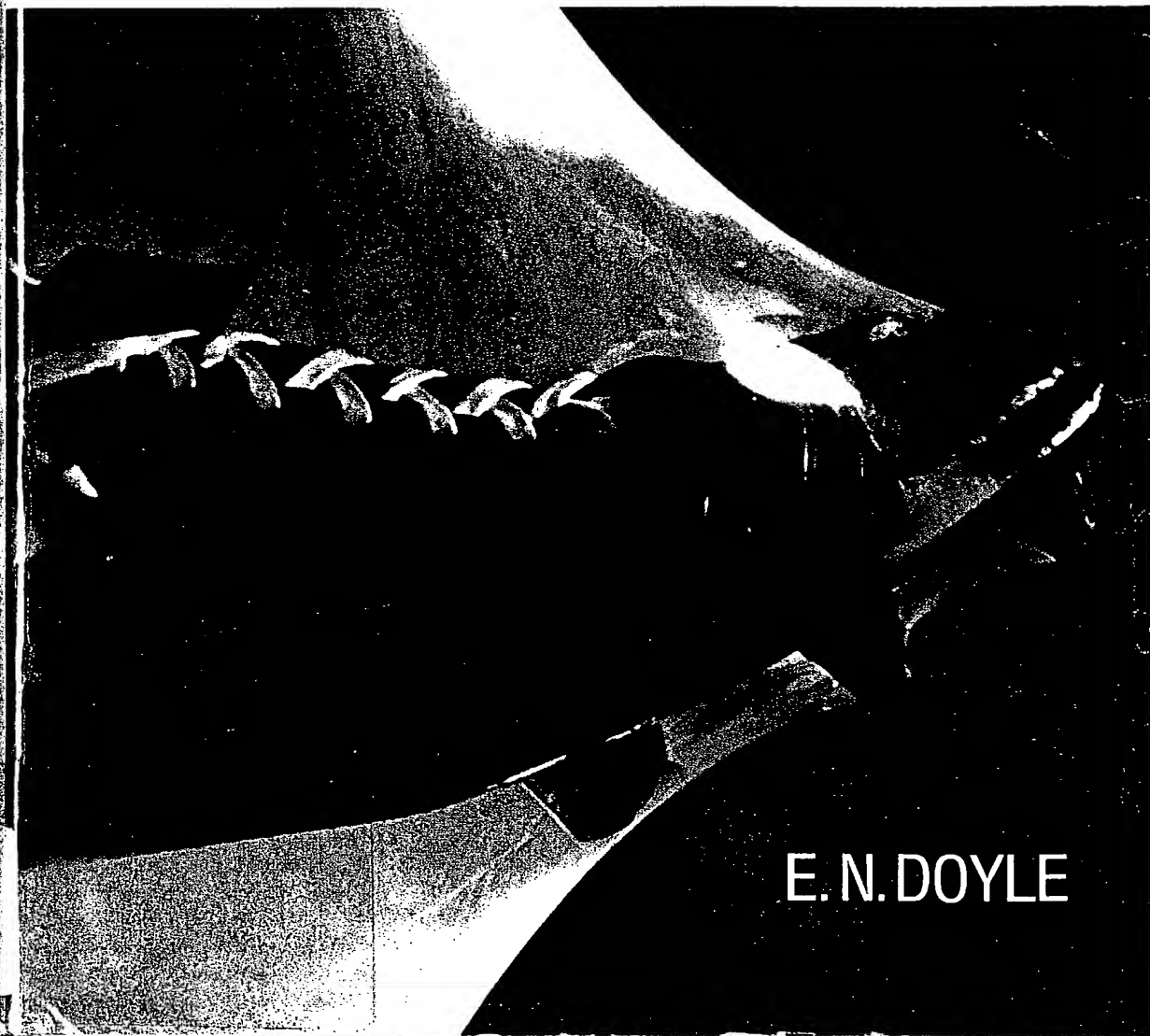
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THE DEVELOPMENT AND USE OF

# **polyurethane products**

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E. N. DOYLE

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THE DEVELOPMENT AND USE OF  
POLYURETHANE PRODUCTS

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the polyether or polyester. A very small equivalent of such a material as sorbitol or pentaerythritol will solve the reactivity problem very nicely.

2. *Tensile strength.* Tensile strength in urethanes is achieved through high percentages of aromatic, urethane, and ester groups. See Chart 1 and Table 2 for information on formulation for this particular property. As stated before, high tensile strength does not necessarily mean high tear strength, and the reverse is also true. Tensile strength does usually coincide with good chemical resistance. Urea groups will give good tensile strength when accompanied by the proper percentages of the groups above, but the urea groups must be nearly equal to the aromatic group percentages in order to achieve this. See Tables 4 and 9, to correlate tensile strengths with end groups when these end groups are close to equal, and compare tensile strengths accordingly.

3. *Thermoplastic.* A thermoplastic urethane is a linear urethane with no branching or cross-linkage. It will be very high in aromatic and urethane groups, accompanied usually by high percentages of ester or ether groups, or both. It is a millable material, which upon heating will become soft and workable. It may be used in fiber, film, or moldings. As a rule, a thermoplastic urethane will have low heat resistance, low chemical resistance, and low solvent resistance. It can have very high tensile and tear strengths when properly formulated. Its elongation will be high invariably, and its Durometer A hardness can range from 25 up to about 85.

4. *Thermosetting.* A thermosetting urethane differs from the above in that it cannot be milled and molded under heat. It can have any degree of branching and cross-linkage, from slight to very high. It may range from a soft elastomer to a very hard polymer. The thermosetting urethane is much more versatile in that it can be formulated to suit almost any chemical environment, and to meet almost any specific property requirement.

5. *Thickness of sections.* In coatings, castings, and moldings, the thickness of the section will control to some degree the gel and cure times. The greater the volume of material, the higher the exotherm temperature will be. To some degree, the thickness of section can affect the end properties, in that with most formulations, the differential in exotherm from a thin to a thick section can cause more complete cures, with slightly better cross-linkages occurring at the higher exotherm temperatures.

6. *Thixotropy.* Thixotropy differs from viscosity in that viscosity is measured by a materials resistance to pouring, while thixotropy involves a material which although very viscous when still, may become quite liquid and fluid when mixed and stirred. Thixotropic agents are used widely in coatings to be applied to vertical surfaces. The ½-sec and

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